

MAINTENANCE AND MANAGEMENT SYSTEM OF INCHEON BRIDGE

Son, Hyeok-Soo

Deputy General Manager, Ph.D., Seoyeong Engineering Co., Ltd.
shssge@seoyeong.co.kr

Ma, Oi-Cheol

General Manager, Seoyeong Engineering Co., Ltd.
ocma@seoyeong.co.kr

Lee, Jun-Ho

Executive Manager, Dagil Industry Co., Ltd.
leejunho21@daroad.co.kr

Kim, Joon-Young

Executive Manager, Incheon Bridge Co., Ltd
joonyoung@amec.com

Abstract: Bridge maintenance and management are extremely important in extending serviceable life of structures. Structure condition deteriorates for many reasons, among them are increased truck volume and weight, environmental elements and the lack of maintenance activities. This paper gives an introduction of the maintenance and management of the Incheon Bridge(private investment project region) with particular focus on maintenance manual of bridge elements inspection and BMS(bridge management system).

Keywords: bridge, maintenance, management, inspection, elements, BMS

1. INTRODUCTION

Bridge maintenance intends to secure user safety and smooth traffic flow by finding abnormalities and damage of the bridge in an early stage and by taking proper measures for them. The maintenance also aims to obtain data necessary for bridge maintenance and management to be carried out afterwards.

Following are the objectives of bridge maintenance.

- 1) Secure and guarantee bridge safety which satisfies design objectives.
- 2) Record bridge condition systematically and periodically.
- 3) Find abnormalities and predict damage to be caused afterwards.
- 4) Provide data necessary to make decisions with regard to repairs, reinforcing, and reconstruction.
- 5) Set up a reasonable maintenance plan based on computerized data of bridge inspection results for optimum distribution of budget.
- 6) Analyze accumulated bridge inspection results for improvement of design and construction of bridges.

There are various objectives of bridge maintenance and the most basic objective is to guarantee user safety by checking bridge condition regularly through field inspection and by preventing or finding in an early stage the damage to negatively affect bridge safety and serviceability. Through analysis on accumulated inspection results, bridge condition which changes with the passage of time can be predicted and thus a proper maintenance plan can be set up. In addition, problems and improvement

measures with regard to maintenance can be analyzed, enabling the design and construction of bridges to consider maintenance and, consequently, bridge life can be extended.

2. OUTLILE OF MAINTENANCE AND MANAGEMENT SYSTEM

Incheon Bridge is a sea-crossing bridge that connects Songdo City with Incheon International Airport(Yeongjong Island). Incheon Bridge consists of the bridge section of the toll plaza side and the viaducts, approach bridges, and cable-stayed bridge of the main road side. Design and construction of the bridge are carried out by fast-track approach. Incheon Bridge is the longest sea-crossing bridge in Korea measuring 11.658km in length including the length of the cable-stayed bridge which has an 800m main span. The design speed of the bridge expressway is 100km/hr and the allowable maximum vertical grade is 3% while it is 2% for horizontal grade.

- Sea-crossing bridge section : 11.658km(6 lanes)
- Toll plaza : 0.685km(14 lanes)

Part of the cable-stayed bridge and the approach bridge has Ship Impact Protection structures(dolphin type) that resist collision with a 100,000DWT vessel. Meanwhile, the main navigation route is the space(625.5m x 74m) between pylons of the cable-stayed bridge.



Figure 1 : Aerial view of Incheon Bridge (Private Investment Region)

2.1 Structural Classification

Classifying the bridge's structural system is a core part of bridge maintenance. With the structural classification, the standards for the maintenance and management of Incheon Bridge can be set taking into consideration the structural features of the bridge.

All structures composing the bridge are made into a tree to form a bridge maintenance system. The established system includes all bridge data(maintenance manual, design drawings, damage mapping system, damage, methods of repairs and strengthening) and inspection data(methods, plans, and substance of inspection) as shown in Figure 2.

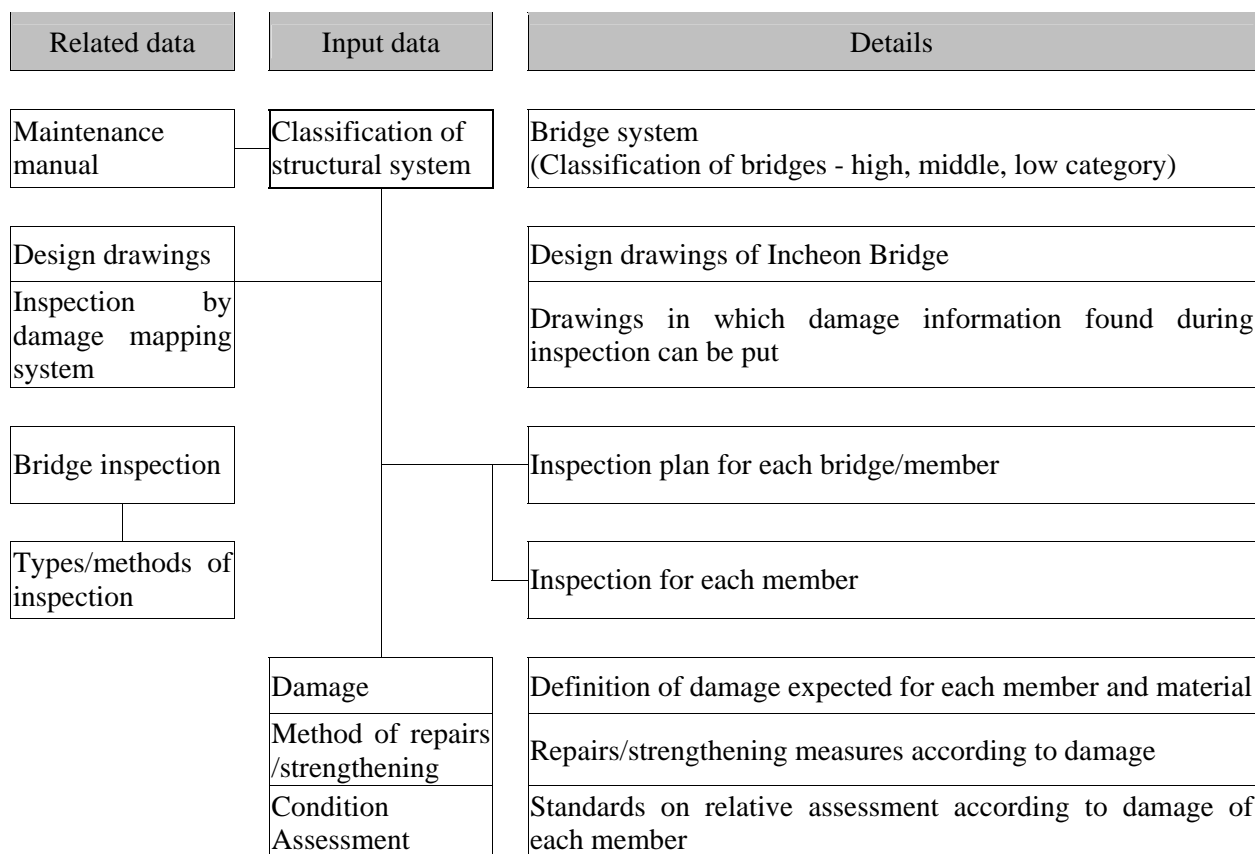


Figure 2 : Concept of bridge maintenance and management system

Table 1 : Structural classification of Incheon bridge - High Category

Bridge		Items on High Category
CSB	Superstructure	Road surface pavement, drain facilities, safety barrier/median strip and railing, box girder, deck slab, diaphragm, expansion joint
	Cable	Stay cable, tie-down cable
	Substructure	Main tower, bearing, pier, foundation
Approach	Superstructure	Road surface, drainage facilities, safety barrier, box girder, deck slab, diaphragm/cross beam, Expansion joint
	Substructure	Bearing, pier, foundation
Viaduct	Substructure	Bridge deck pavement, drainage facilities, safety barrier, box girder, deck slab, diaphragm, expansion joint
	Substructure	Bearing, pier, foundation
Toll Plaza	Superstructure	Bridge deck pavement, drainage facilities, safety barrier, deck slab, preflex girder, cross beam, Expansion joint
	Substructure	Bearing, abutment, pier, foundation
SIP and SP		Ship Impact Protection, Scour Protection

Bridge was classified based on design drawings and the classification becomes the standards of all maintenance items (inspection, condition assessment, repairs, strengthening).

With the management system established for each bridge, bridge condition can be regularly checked during the service life of the bridge. And, the damage that can possibly affect the bridge's safety and serviceability can be prevented or found in an early stage to take proper actions.

By analyzing the durability and load-carrying capacity of bridge through the history management of each bridge, the bridge condition changing with the passage of time can be assessed. And, proper maintenance plans can be set up according to the results of assessment results.

That is to say, for reasonable bridge maintenance, the classification system of bridge structure, which can input, search, and analyze the information of each bridge member and comprehensively manage the results for each bridge, is required. All members of the bridge are put in high category, middle category, or low category and the members put in the low category were subdivided into four(4) steeps from I to IV. Table 1 shows the high category of Incheon bridge.

2.2 Maintenance System

Table 2 : Maintenance system of Incheon bridge

Category	Items	Details
Maintenance facilities	Maintenance office Required personnel and Equipment Maintenance facilities	Propose an optimum operation plan. Propose the organization and maintenance equipment related with BMS and measuring. Propose maintenance facilities and operation plan of the facilities.
Maintenance manual	Structural features of bridge	Data analysis on the type of each bridge
	Classification of structural members	Making an inventory for systematic classification
	Periodical inspection items of bridge	Providing an inspection period appropriate for laws/regulations and structural features
	Inspection items of each bridge member	Major functions of each member, inspection items to sustain functions
	Details such as inspection access	Details such as inspection access
Bridge Maintenance System (BMS)	Inspection management program	Management of inspection plans and database Proposal of comparative assessment methods and repairing/strengthening methods
	Inspection sheet program	Proposal of inspection result inputting method
Safety assessment methods	Methods to connect with automatic measuring	Specify the method to connect automatic measuring data and inspection data
	Items for periodical safety assessment	Specify periodical safety assessment items and assessment methods.
	Safety assessment items of each member	Specify the items and methods of safety assessment for each member.
	Assessment grade for each item	Specify the safety assessment method for each item and the specify the grade.
	Safety assessment method	Specify the periodical safety assessment method for each member.

The maintenance of Incheon Bridge includes all the works to keep safety and functions of bridge and to secure convenience and safety of vehicles such as daily maintenance of existing facilities (cleaning,

replacement of signs and street lights, lane coloring, etc.), recovery of damaged parts, and adding facilities for facility supplementation. Concerning maintenance methods, all the items related with general inspection, regular inspection, detailed inspection, emergency inspection, detailed safety assessment, measuring, reconstruction, repairing/reinforcing, and damage control of structures are included. Table 2 shows the schematic maintenance system of Incheon bridge.

3. MAINTENANCE MANUAL AND BRIDGE MANAGEMENT SYSTEM

The maintenance manual describes the maintenance plan, the type of the inspections and their frequency, the safety evaluation, the emergency maintenance, the preventive maintenance and the repair and strengthening. Maintenance manual of Incheon bridge provides general and detailed items about bridge system to facilitate systematic and efficient operation with regard to inspection, assessment methods, and maintenance methods for the safety inspection and maintenance of Incheon Bridge. Incheon bridge maintenance manual, general work standards required for the maintenance of various facilities are provided based on the "Special Act of Safety Control for Facilities" which is applied to the safety/maintenance of facilities. This manual also provides the requirements necessary for the safety and maintenance of Incheon Bridge in accordance with "Guidelines for Safety Inspection & Detailed Safety Assessment" which is announced by the Ministry of Land, Transport, and Maritime Affairs in Clause 13 of the Special Act and in Clause 13 of the Enforcement Ordinance of the Special Act.

Table 3 : Main features of maintenance manual

Item	Main features of maintenance manual
1. Maintenance plan	<ul style="list-style-type: none"> - General items about maintenance - Project overview, organization, operation plan - Laws and regulations for maintenance
2. Classification of structural system	<ul style="list-style-type: none"> - Standards on structural classification for effective maintenance of Incheon Bridge, Classification of each bridge - Composition of database system for bridge maintenance - Classification of CSB, approach bridge, viaduct, toll plaza, SIP - Classification of members of the whole bridge
3. Inspection system	<ul style="list-style-type: none"> - Inspection plan, inspection details, inspection methods for each member(inclg. underwater investigation) - Inspection plan, access, detailed inspection, inspection methods, actions
4. Assessment of condition and safety	<ul style="list-style-type: none"> - A comprehensive method for relative assessment, durability test, load-carrying capacity assessment, safety test after inspection, Assessment of the final grade of the whole bridge - Assessment methods and procedures
5. Emergency maintenance	<ul style="list-style-type: none"> - Emergency measures for unexpected conditions occurred during bridge service - Emergency inspection(earthquake, storm, collision of vehicles and ships, fire), winter preparation, countermeasures for storm and flood, fog, disasters, and workplace safety are included. - Safety management of workplace
6. Preventive maintenance	<ul style="list-style-type: none"> - Prevent(delay) damage of major members with preventive maintenance methods - Method that optimizes bridge life and its corresponding cost - Preventive maintenance of each member
7. Repairs/strengthening	<ul style="list-style-type: none"> - Repairs/strengthening for damage and reduced durability that could occur during service to major members
8. Maintenance facilities	<ul style="list-style-type: none"> - Maintenance measures of inspection facilities for maintenance

BMS(Bridge Management System) is an information system where the manager can comprehensively control the information of the whole bridge. BMS provides various information the manager needs in establishing plans related with bridge maintenance. And, it also helps the manager to determine the material quantity required for bridge maintenance both at present and in the future in the most optimal way. The data stored in BMS are utilized in various ways as information the manager needs through technical assessment and economy analysis. Such information will be utilized as basic data in establishing maintenance plans and strategies for the whole bridge. Followings are the expectations based on the composition and utilization of Incheon bridge BMS.

- 1) Secure safety by preventing damage to the bridge and other facilities.
- 2) Extend the endurance period by preventing aging of the bridge and other facilities.
- 3) Improve convenience and perform effective maintenance by establishing a computation system.
- 4) Carry out tasks promptly and accurately. Provide mathematical and statistical data.

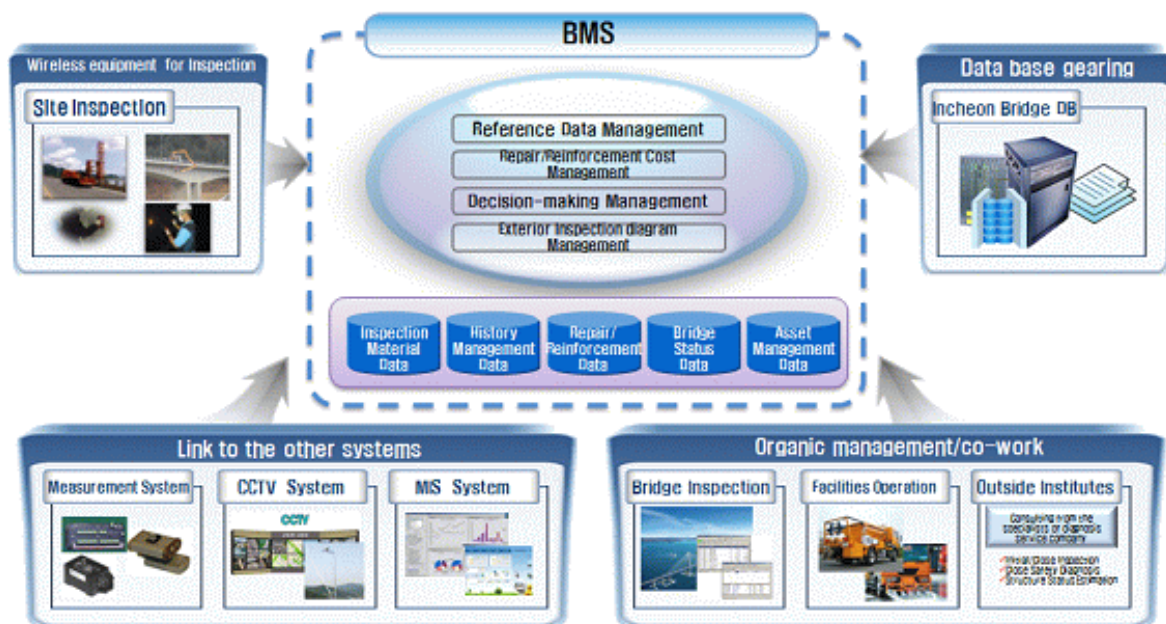


Figure : 3 Outline of Incheon bridge BMS

4. CONCLUSIONS

Bridge maintenance is extremely important in extending serviceable life of structures. Structure condition deteriorates for many reasons, among them are increased truck volume and weight, environmental elements and the lack of maintenance activities. This paper gives an introduction of the maintenance of the Incheon Bridge(private investment project region) with particular focus on inspections of bridge elements and BMS(bridge management system). To achieve an effective bridge maintenance program, it is necessary to apply the right treatment, to the right structure, at the right time. The maintenance and management system of Incheon bridge helps bridge administrators to establish the rational maintenance strategies.